



INL physicist Gus Caffrey helped invent devices to discern the contents of mystery munitions and used fuel casks. His contributions over 32 years earned him INL's Lifetime Achievement Award this year.

Life applied: Physicist's work brings satisfaction, international accolades

By Nicole Stricker, *INL Communications & Governmental Affairs*

Ask A.J. "Gus" Caffrey about his work and you'll get a short history of U.S. chemical warfare agents. He'll set down his coffee cup, lean back in his chair, point to a photograph of a rusty artillery shell unearthed in 1993, then reconsider and begin his answer at World War I.

The Idaho National Laboratory physicist is as passionate about history as he is about his own research, science in general, powder skiing and just about everything except talking about himself. But military history is relevant since his signature technology helps demystify it.

Caffrey invented a device to nondestructively discern the contents of munitions that may contain chemical warfare agents, explosives, smoke generators or benign practice materials. It received an international award 20 years ago and is used around the world today. A newer invention that can passively verify the contents of used fuel casks aspires to a similar fate.

That may be why, despite receiving INL's Lifetime Achievement Award this year, Caffrey shows no sign of slowing down. Even after spending his entire working career at the lab, he retains a passion for work and for meeting new colleagues, especially those who appreciate his science-based humor.

"This year, I turned 64, which makes my half-life 32," Caffrey jokes. "That means I've spent a half-life at this lab."

Mystery munitions

For most of his INL career, Caffrey has focused his energy on "the assessment of dangerous things you'd rather not open." Suspected chemical warfare munitions received the bulk of his attention, and his work helped the government enforce "a treaty, absent robust monitoring tools, that you can cheat on with a can of spray paint."

During World War I — which some called "the chemist's war," says Caffrey, as opposed to WWII, the "physicist's war" — munitions contained a variety of chemical agents with names ranging from the common (mustard gas) to the exotic ([O-ethyl-S-\(2-diisopropylaminoethyl\) methyl phosphonothioate](#)). Yet the artillery looked identical from the outside. Only paint color-coding and stenciled markings indicated the contents.



Caffrey works on detectors in the PINS lab. The units can discern potentially dangerous contents of artillery shells.

This predicament complicated international treaty enforcement. It also presented risks to U.S. soldiers [dealing with recovered munitions](#) that lost their markings due to corrosion. So the U.S. Department of Energy's national laboratories were asked to devise a solution. The chosen approach: one led by Caffrey's team and still in demand today.

The [Portable Isotopic Neutron Spectroscopy](#) (PINS) system performs a type of chemical analysis that can reveal what's inside an artillery shell without opening it. PINS does this by shooting tiny bits of energy (neutrons) at a shell and measuring the energy (from gamma rays) that emerges from it. The key to success: every chemical element reacts differently to the energy and emits a distinctive response.

Think of a group of children, each presented with a surprise gift. Each child absorbs this exciting news and expresses it differently. One may shriek while another jumps up and down. One may giggle while another's eyes and mouth pop open. Somewhat similarly, every element on the periodic table de-excites by emitting a characteristic burst of gamma rays.

"So by analysis of the gamma rays that come off the artillery shell, you can figure out what chemicals are inside," Caffrey says.

Artillery PINSpections



Caffrey received INL's Individual Lifetime Achievement Award from Lab Director John Grossenbacher, left, at the 2012 Honors Reception.

The PINS software analyzes gamma emissions from a mystery munition, determines the mix of elements inside and deduces the payload. It can distinguish between a host of chemical agents as well as simple explosives, smoke generators and even dummy materials such as plaster of Paris. And it [accomplishes all this in a matter of minutes](#) using a simple computer interface that keeps the human operator at a safe distance.

This year marks the technology's 20th birthday and the anniversary of the year it won an [R&D 100 Award](#) as one of the best inventions of 1992. Today, PINS is a commercial product of the ORTEC division of [Ametek, Inc.](#) The technology is used throughout the nation and the world, including by U.S. soldiers stationed abroad.

"It was first adopted for the Chemical Weapons Convention, and then the Army decided they'd like to use it for the cleanup mission, and then the soldiers decided they'd like to use it on their own and take it to the field," Caffrey says. "So it's been taken to Iraq and all around the world."

Caffrey's INL team is still heavily involved in the technology. The team is expanding the library of chemicals PINS can identify and trying to enhance its algorithm to speed the ID process. The team also trains new users, both internationally and at home.



"The Canadians want a PINS class some time; the Australians are going to have one in November or December," Caffrey says. "I think it's kind of neat, and the military people do, too, that the actual inventors of an instrument come and teach their soldiers how to use it." The PINS technology has been used by law enforcement and military personnel through the U.S. and the world. [Click for larger image.](#)

Asked how a basic physicist became so passionate about applied military technology, Caffrey says simply, "It's a matter of supporting our soldiers." His sentiment stems in part from the period when he was drafted in 1969. "It was a really good experience, but it was an unplanned two years out of my otherwise quiet life."

Life transitions

Caffrey grew up north of Boston and signed up for high school physics a year before most students. At the end of the course, he had more questions than answers and never really appreciated the science until he completed calculus in his senior year.

By then he was sold — he ended up majoring in physics at the [College of the Holy Cross](#) in Worcester, Mass. In graduate school at the [Johns Hopkins University](#), after his stint as an infantryman, he narrowed his focus to gamma ray and neutron spectroscopy. As graduation neared, he saw an ad for a job at Idaho's national lab.



Caffrey and physicist Ed Seabury, left, make adjustments to the Compton Dry-Cask Imaging Scanner.

"I didn't know about it," he said of the lab. "At the time, I didn't know much about the Western states so I thought I should take a look at it."

When he arrived for an interview, three of his four escorts had surprisingly familiar names — they were the authors of an important reference book in his field. "I was sort of intimidated," he says of the unexpected encounter. "I thought, 'Wow, this would be a pretty good group to join.' And when I did, I was mentored by these guys."

He did basic research "for the better part of 10 years" before his work started moving into the applied realm. That shift brought added fulfillment from working with engineers, teaming with scientists in other disciplines and seeing an idea come to practical use.

"Most physicists do stuff that's not released or practiced in their lifetime," he says. "It's not something a commercial product is based on, and it's not used by your countrymen right away."

Latest ambitions

Another of his inventions could soon prove useful for both countrymen and the [International Atomic Energy Agency](#) (IAEA). The Compton Dry-Cask Imaging Scanner (CDCIS) enables inspectors to discern the contents of a nuclear fuel storage cask without having to open it. The device sits atop a closed cask, scans each of its 24 slots, and reveals the presence or absence of fuel rods at each position.

Once again, gamma rays are the key to success. Nuclear fuel radiation scatters so widely that a traditional Geiger counter couldn't differentiate the contents of individual slots. "Scattered gamma rays are less energetic, so you can calculate where there is a rod and where there isn't," Caffrey says.

The device allows inspectors to independently verify storage records without having to open the casks. It also can help when records aren't available or reliable. Caffrey's team is taking the scanner to Belgium this fall to help the IAEA verify the contents of some dry fuel casks. The team envisions routine use by the IAEA, and eventually, long-term U.S. storage facilities.

The invention was nominated for an R&D 100 Award in 2011. The following year, Caffrey received an even bigger honor: an INL [Lifetime Achievement Award](#). "It was a complete surprise," he said.

The award acknowledges the lifetime achievements of a colleague who has made nationally- and internationally-recognized contributions to advance a field of study in science or engineering.

"In addition to exceptional scientific achievements, Gus has mentored three Idaho State University master's degree students, taught University of Idaho courses, trained hundreds of soldiers and advised dozens of colleagues," said Laboratory Director John Grossenbacher at the 2012 INL Honors Reception. "Gus is a valued member of the National and Homeland Security staff at INL and is helping to make the United States a safer place."

Yet Caffrey is one of those people who plays as hard as he works. He likes to go hiking and do a little rafting in the summer. He picks Idaho huckleberries in the fall. He recently gave up his running passion to focus more on bicycling. But his real love is powder skiing.

He hits the slopes an average of 30 days per winter. And as a 10-year member of the [Grand Targhee](#) ski patrol, he's often among the first on the mountain after a snowstorm.

"It's nice when I get to make first tracks," he says. "When I came here, I didn't know how to ski in powder. It took awhile to learn, but there's nothing better."

Yet Caffrey shows no inclination to make recreation his full-time job. When asked about retirement plans, he takes a long pause before saying, "I have some interesting new challenges." Then he begins describing a new PINS application he'd like to try.

(Posted Oct. 24, 2012)

[Feature Archive](#)